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STIFFNESS TESTER

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ABSTRACT

Majority of manually operated fabric stiffness tester uses a light source and a person lie at 41.5º, On which a shadow at the fabric under test is formed and the length is measured using steel ruler. However, with this approach only length is measured at a final bent angle (41.5º) of the fabric.

Our approach uses the above methodology with automation for fabric feeding and measuring of intermediate lengths and bending angles using a light intensity sensor mounted on a rotating disc connected to an encoder and a stepper motor. The bending angles are automatically noted and can be recorded in excel sheet, further reports can be generated in tabular and graphical format.

***KEYWORDS**: Fabric, Tester, Light Source & Stepper Motor*

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Original Article

INTRODUCTION

Tz Fabric stiffness is considered as an important factor in the evaluation of the comfort and wear of apparel fabric. The aesthetic effect (Drapabiltity) of any fabric depends on fabric stiffness. An attempt to evaluate the hand of a fabric in the laboratory is made difficult by the fact that no specific definition at hand exists, nor indeed does a specific definition exists of many of its components such as stiffness, resilience, compressibility etc. But the problem was measuring of these properties in such a way that the result will mean something to the man who is accustomed to handling fabrics

Several testing devices offer the function to test the bending rigidity of the fabrics. Not only that, they come with various principles of measurement such as a pure bending principle, folded loop and cantilever methods. A commonly used principle, cantilever deformation is a globally accepted principle which was originally initiated by Peirce [10]. During the experiment, one edge of the fabric strip is fixed on a platform, glided with a ruler and deflected from the platform under its own weight as a cantilever. Then, the cantilever length is measured once it reaches a pre-determined deflection angle.

According to Pierce, bending length C is the length of the rectangular strip of material which will bend under its own mass to a fixed angle. For ease of measurement, this method uses the cantilever length corresponding to the angular deflection θ = 41.5°, so that the bending length is half of the cantilever length as shown in the following equation. Hence, double the bending length or the overhang length was read from the ruler when the tip of the sample touched the red line of 41.5° on the apparatus (see Figure 1). The higher the bending length, the stiffer the fabrics.

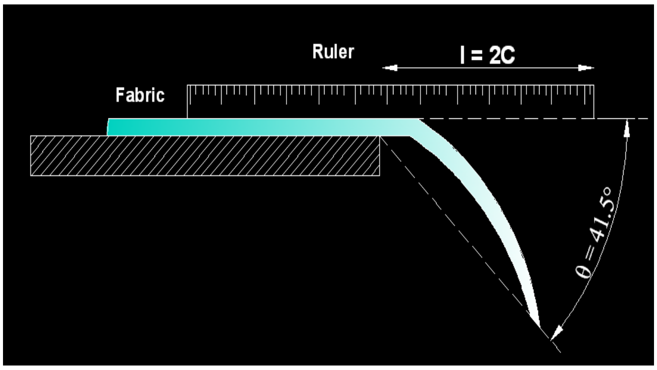

Figure 1: Schematic Diagram of Bending Test According to BS 3356-1990 Standard Method

Bending length C is given by the formula (1), where we used θ = 41. 5°, and l is the sample overhang length at that angle. By using the appropriate mean value, the flexural rigidity (G) of the fabrics is determined by the standard using formula (2), where C is the bending length (cm), and M is the fabric mass (g/m2). In the standard method, the unit is not given in a standard unit (SI). With SI units, the flexural rigidity of a plate is the force couple (Nm) required per width (m) to bend the plate in one unit of curvature (1/m), and hence has the general unit for a plate of Nm.

$$\mathrm{C} = l\left(\frac{\cos(\theta/2)}{8\tan\theta}\right)^{1/3} = l/2, \tag{1}$$

$$\mathrm{G} = 0.10\ \mathrm{M}\ \mathrm{C}^3\ (\mathrm{mg\ cm}) \tag{2}$$

Many researchers applied this principle and developed their own test method for the determination of bending.

In the present work a new automated bending tester is developed on same cantilever principle, to reduce the human interference in the bending measurement with this instrument, by making controlled specimens, behaviour of sample at every millimeter(mm) can be studied. Bending angle can also be measured for every millimeter(mm) with the help of sensor and white LED (light emitting diode) as a light source. The bending angles are automatically noted and can be recorded in excel sheet, further reports can be generated in tabular and graphical formats.

PRINCIPLE

The fabric moves in steps of – 1mm, 2mm, 5mm or 10mm (as selected by the user in the software interface) and the shadow measuring disc is rotated with 1 degree steps starting from 0 degrees till a maximum angle of 50 degrees, and the darkest region is computed by the intensity sensor and software to evaluate the bending angle. This is repeated until the fabric reaches or crosses the final bending angle of 41.5 degrees. Every time the length and bend angle is stored in a database and finally a graph is plotted which shows the length Vs bending angle line plot.

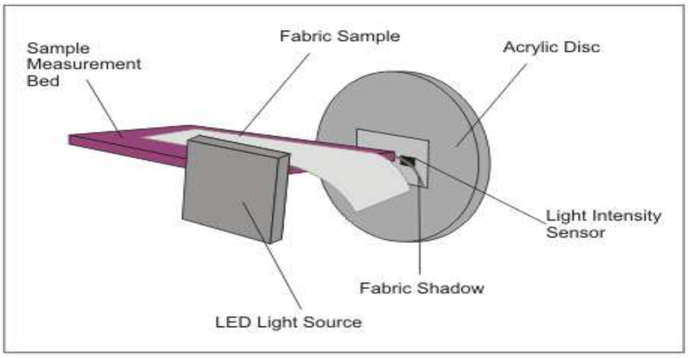

Figure 2

DESIGN OF INSTRUMENT

The system is designed using an ARM Cortex based microcomputer board featuring – ARM Cortex A7 Cpu (Quad Core) running at 966MHz, 2GB PRDDRAM, built in BLE, WiFi, LAN, and 4 x USB ports with additional GPIO ports consisting of I2C, SPI, UART, and Parallel interfaces. The system features HDMI and CVBS video outputs for connection to composite video input and HDMI or VGA monitors.

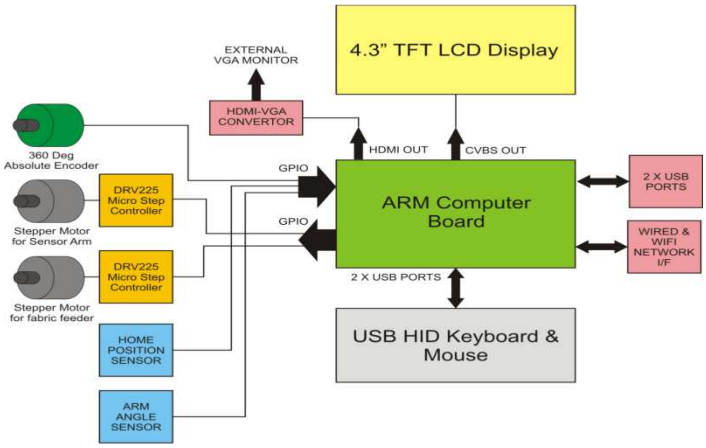

Figure 3: Block Representation of Electronics and Mechanical Components

As seen in the above block representation the mechanical part of the system consists of 2 x stepper motors for controlling fabric feed and detection of angular bending, the 2nd motor is coupled with an absolute type rotary encoder with 1 degree resolution for detection of bending angle of fabric. Two different sensors are used for detection of home position of fabric feeder and sensing bending angle of fabric respectively.

The fabric feeding mechanism is a belt driven type and uses a GT2 type timing belt, the feed motor – type NEMA23, is mounted with a GT2 type timing pulley and an idle pulley is mounted along the axis end. The GT2 timing belt is coupled to a fabric slider fabricated using acrylic sheet, and also consists arrangement for fastening of the belt ends.

The fabric feeder home position is sensed using a limit switch mounted at the extreme left hand side of the axis which is the home position of this axis. Before incrementing the feeder the software moves the feeder to this home position, wherein the switch trigger point is considered as home position, and the feed increments are relative to this zero position. Fabric can be moved in steps of 1mm, 2mm, 5mm and 10mm

The fabric bending angle is detected by measuring fabric shadow formed on a detector disc mounted on the 2nd stepper motor type NEMA17, which is also connected to an absolute rotary encoder type Autonics EP50S8-360, capable of measuring 360 degrees angle with 1 degree resolution. A light source is fabricated using SMD 0805 type white LEDs for the shadow formation. The detection disc is mounted with a light intensity sensor type BH1750 manufactured by ROHM semiconductor, which can measure light intensity in LUX with a resolution of 1Lx.

The detection disc is aligned to 0 degrees and every time the fabric is moved along the movement axis the detection sensor is reset to 0 degrees and then is rotated up to 50 degrees taking light intensity measurements per degree. These values are then sorted by the software and the minimum light intensity angle is considered as the bend angle of the fabric. Every time the length and bending angle is stored in a database and finally results are displayed in 4.3inch TFT LCD model

RESULTS AND DISCUSSIONS

The equipment is tested with commercial samples and results are matched with the Shirley stiffness tester. The repeatability also showing consistence results, this equipment has been calibrated from Tiruppur testing Services, Tirupur (Calibration date 13/09/2017 Certificate nos TTSCR171904)

Table 1: The Basic Properties of these Fabrics

Type of Fabric	Warp Count in Tex(Ne)	Weft Count in Tex (Ne)	EPC	PPC
Grey Cotton	14.1(42)	17.4(34)	27	18
Bleached Cotton	2X21.1(2/28)	2X21.1(2/28)	24	22
Toweling	32.8(18)	32.8(18)	18	14

Three samples were tested on Shirley Stiffness tester and Automated tester. The test is carried out by moving the fabric at 2, 5 and 10 mm/min in Automated tester. This provision is not there in Shirley tester. The measurement records the bending angle in degrees. The test is stopped at 41.5 deg in Automated tester. The result is given in Table 2.

Table 2: Results of Deflected Length on Shirley Tester and Automated Tester

	Shirley Tester	Automated Tester Results		
		2 mm	5 mm	10 mm
Grey	20.75	22.60	20.00	24.00
Bleached	21.00	14.40	15.00	20.00
Toweling	20.75	22.20	23.00	23.00

Variance test was carried out using MS-Excel. The F value of 1.367 (p-value= 0.3628) between Shirley tester and Automated tester at 10 mm/min clearly indicates that the results obtained on Automated tester agrees with results of Shirley tests. Further the F-value of 2.73322 (p-value=0.1786) between various traverse rates of sample on an automated tester also doesn't show significant difference.

The assumption in Shirley tester is that fabrics bends like cantilever. But fabrics being flexible, more often will not show such bending behavior and at any critical length, bending resistance falls rapidly. This is very much evident when we observe the plots shown.

Grey Fabric

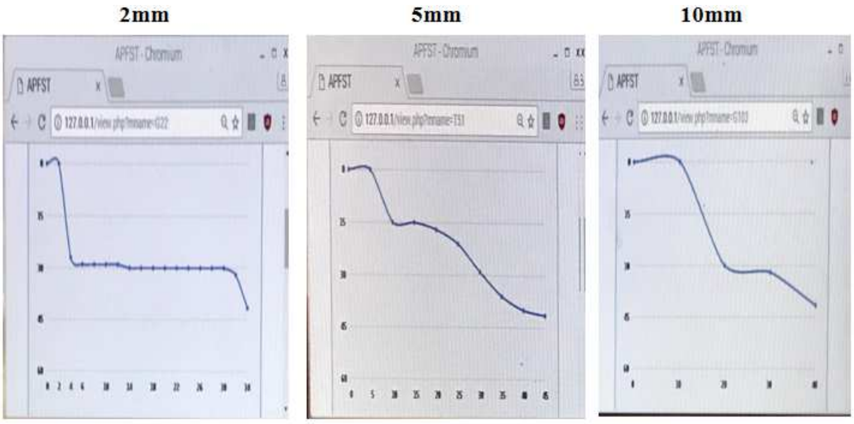

Figure 4

Bleached Fabric

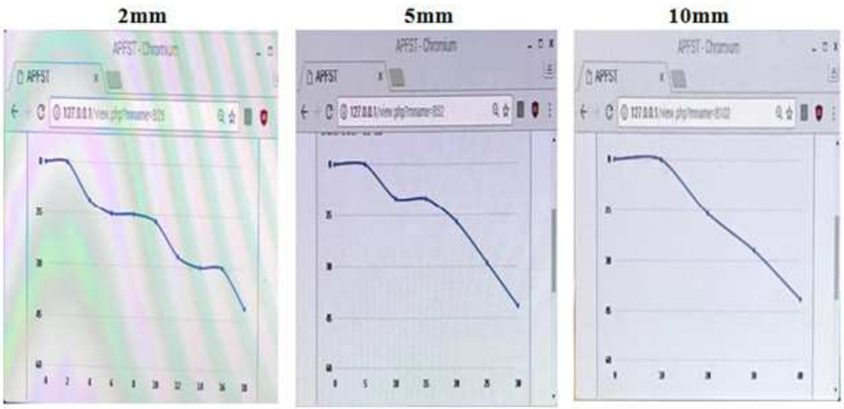

Figure 5

Towel Fabric

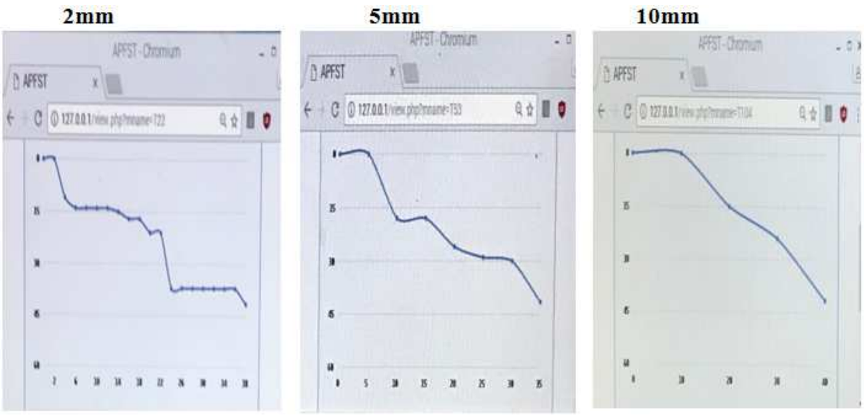

Figure 6

CONCLUSIONS

The equipment is tested with commercial samples and results are matched with the Shirley stiffness tester. The repeatability also showing consistence results, this equipment has been calibrated

The new design employs automated to a large extent with feature of quick computation, instant display with enough data storage facility enabling export to USB flash drives and portability to latest Microsoft excel files and graph generation. In short, this is user friendly with easy handling features. Perhaps its greatest feature being evaluated for a large bending angle range between 0 to 90^0 with 1 degree resolution.

The new insight of fabric stiffness is expected to assess fabric hand, keeping customer focus, user friendly at affordable cost.

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